A Validation of Prescription Parameters
Bandelier National Monument
Management Ignited Prescribed Fire
Upper Frijoles Units 1 and 5
May 16, 2000

Abstract: Prescription parameters for the Upper Frijoles Units 1 and 5 Prescribed Fire Plan were set to establish a relatively wide window of opportunity to facilitate burning across a diverse vegetative profile. Prescriptive parameters were found to be generally sound and applicable towards achieving project objectives, except in some extreme cases. Strictly from a fire behavior and fire effect perspective, the fire plan was adequate and appropriately implemented.

Introduction

Upper Frijoles Units 1 and 5 are located in the northwest corner of Bandelier National Monument, encompassing approximately 1,000 acres of ponderosa pine/mixed conifer and montaine grasslands situated between 9,000 and 10,000 feet MSL.

The purpose of the project was to reduce hazardous fuels and allow fire to be restored as a natural process. Project objectives sought to remove dead surface fuels and cured herbaceous material and modify the mid-story structure of the existing stands. Fire behavior indicators were the means of determining if prescription parameters were met.

The intent of this report is to document the validity of the prescription parameters of the Upper Frijoles 1 and 5 Fire Plan, based on fire behavior/weather relationships and the ability of prescribed burning conditions to meet project objectives.

I. Prescription Parameters

Fire Behavior Prediction System Fuel Models
Four fuel models were used in developing the fire plan prescription:

Fuel Model 1: Short grass, cured and 1 foot or less in height.

Fuel Model 2: Open timber stand, typically ponderosa pine, with grass understory.

Fuel Model 8: Timber litter beneath a closed stand of short-needled conifer.

Fuel Model 9: Loosely compacted needle litter from a closed stand of long-needled conifer.

Weather
Prescriptive weather and fuel moisture conditions established in the fire plan are listed below.

Temperature:	40 to 90 degrees Fahrenheit
Relative Humidity:	15 to 50 percent
Wind Speed:	0 to 8 miles per hour
Wind Direction:	Any

1 Hour:	3 to 8 percent
10 Hour:	4 to 10 percent
100 Hour:	7 to 12 percent
1000 Hour:	8 to 12 percent

Live Herbaceous:	50 to 150 percent
Live Woody:	50 to 150 percent

Fire Behavior

Prescriptive parameters for fire behavior are also listed, determined by the fire behavior characteristics of the fuel models used in the plan. Rate of Spread is measured in chains (66 feet) per hour and flame length is measure in feet.

Fuel Model	Rate of Spread	Flame Length
1	<160	1” to 9’
2	<60	1” to 9’
8	<10	1” to 6’
9	<10	1” to 6’

Project Objectives

Several objectives were listed in the fire plan. Objectives directly associated with fire behavior include those speaking to tree mortality, consumption, air quality and containment. For brevity, these objectives are paraphrased below.

Reduce poles (trees less than 6” dbh) by 30 to 70% within 5 years post-burn.

- Reduce 6 to 20” dbh overstory trees by no more than 25% within 5 years post-burn.
- Retain 80% or greater overstory trees 20” or greater dbh.
- Reduce total fuel load by 40 to 80%.
- Emissions will not violate 90% NAAQS in Los Alamos and White Rock.
- Contain spots/slopovers at 5 acres or less with burn personnel within one burn period.
- Reduce spotting distances to ¼ mile or less by altering ignition sequence and timing.

II. Findings

Prescription Parameters

Fuel models used in developing the fire plan are appropriate for fuel conditions on the ground. A fuel model 10 may be appropriate in some areas under very dry conditions.

Some conflicts do exist in the prescription between different sets of parameters. The desired maximum temperature and minimum relative humidity values can result in a corrected 1 hour fuel moisture that is outside of prescription (2%) if calculated on unshaded south slopes after 1400 hours.

The fire plan did not specify whether a head or backing fire would be used, though it was stated that ignition techniques could be modified to meet immediate needs on the fire ground. Calculations performed for this analysis assume a running head fire for all worst case scenarios.

The fire plan prescription is built into "square" parameters, i.e., a linear set of high and low values that form a conceptual box that creates the prescription window. This configuration can be problematic when extreme values for each parameter are linked, as calculated fire behavior often exceeds prescribed values. See Figure 1.

Figure 1
Predicted Fire Behavior Under Extreme High End Prescription*

Fuel Model	Desired Flame Length	Predicted Flame Length	Desired Rate of Spread	Predicted Rate of Spread
1	1" – 9'	8.5	<160	**316**
2	1" – 9'	**12**	<160	**123**
8	1" – 6'	1.9	<10	5
9	1" – 6'	5.3	<10	**26**

*Boldface indicates values outside of prescription. Flame lengths are in feet. Rates of Spread are in chains per hour.

At least three distinct vegetation types exist on the landscape: grass, pine-mixed conifer and mixed conifer-aspen. These loosely correlate to the geographic locations of Phase 1, 2 and 3 respectively, as identified in the fire plan. The prescription window in the fire plan is written to allow for a wide range of burning conditions in order to meet the necessary burning conditions to meet objectives in all three fuel types. A considerable amount of local knowledge and expertise would be needed to appropriately apply the prescription in the right amount in the right locations. A better method is to construct distinct prescriptions for each vegetation type, especially if ignitions are separately applied. This would also allow for better understanding of fire behavior and effects between each type.

Observed weather at the time of ignition was solidly within prescribed boundaries for the fuel/vegetation type in which burning occurred. Temperature at ignition was 52 degrees, with 31% relative humidity and upslope winds at 1 to 3 miles per hour. Predicted and observed fire behavior at the time of ignition is exhibited in Figure 2.

Figure 2
Predicted and Observed Fire Behavior at the 2000 Hours on May 4, 2000

	Predicted Rate of Spread	Observed Rate of Spread	Predicted Flame Length	Observed Flame Length
Head Fire	17	16	4.4	3
Backing Fire	2	3	1.4	2

*Rate of Spread is in chains per hour. Flame length is in feet.

The spot weather forecast dated 5/4 at 1220 hours states that weather conditions during the next day's burning period would have temperatures in the low 70's, relative humidities 13 to 15% and (corrected to mid-flame) winds west to southwest at 1 to 5 miles per hour. These conditions are well within prescribed values.

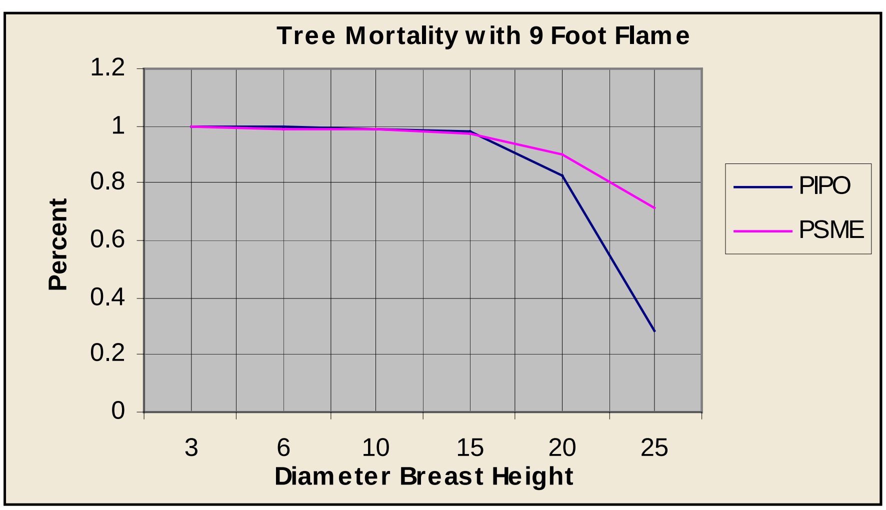
Objectives
Not all objectives are appropriate for all fuel models indicated in the fire plan. For instance, tree mortality is not considered for fuel model 1, a grass model. Consumption objectives may not apply in fuel models 1 and 2 since the bulk of the fuel in the model is in the fine fuel classes, which typically consume completely in the course of a burn.

Mortality will vary by tree species and fire intensity. It is difficult to predict tree mortality in real terms because of the variable arrangement of available fuels and subsequent fire intensities across the landscape. Given this, accomplishment of mortality objectives over a range of tree species and tree diameters with a single prescription can be difficult.

Note: Analysis of aspen objectives was deleted from this analysis to facilitate timeliness of this report.

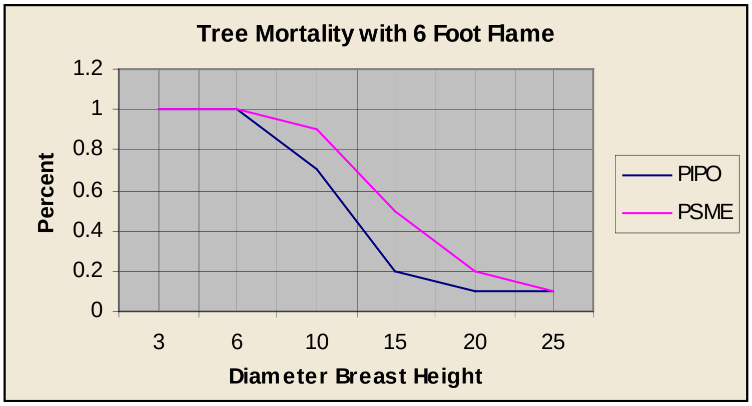
Flame lengths of 9 feet (fuel model 2 max. flame) will over achieve mortality in all but the largest size classes ponderosa pine and Douglas fir. See Figure 3.

Figure 3



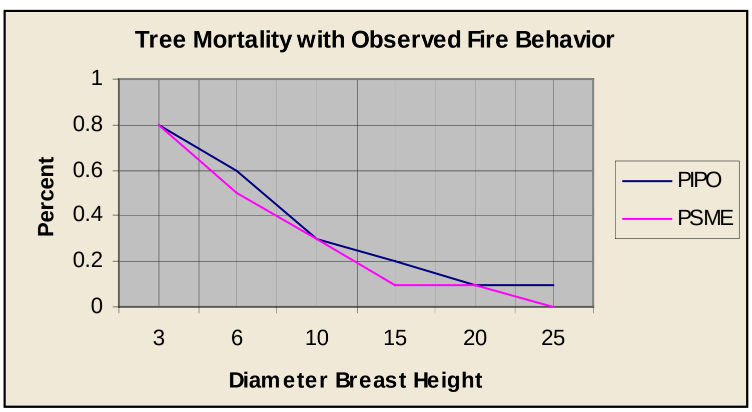
Flame lengths of 6 feet (fuel model 8 and 9 max flame) produces better results. Desirable results are achievable in stands with trees in a 15" diameter class and larger, but overachievement still occurs in trees in the 6 to 15 inch diameter classes. Mortality reaches 100% in trees less than 6 inches in diameter. See Figure 4.

Figure 4



Flame lengths during ignition were observed to be from 6 inches to 3 feet in length. An average flame length of 2 feet produces very desirable results. See Figure 5.

Figure 5



To summarize, the prescription as written will tend to discriminate against young trees, leaving an older, more open stand. This type of stand will be less conducive to sustained torching and crowning and thus mortality objectives are appropriate in that context. If the intent is to leave a stand of diverse size and age classes, then mortality objectives will likely be overachieved under high-end prescription burning conditions. The prescribed burn as it was implemented exhibited very low intensities and mortality objectives were not accomplished.

Thousand-hour fuel moisture is used prescriptively to track fuel consumption. Measured 1000 hour fuel moistures averaged 12% the week before the burn, the low-end prescription value. Fuel consumption was modeled using the FOFEM (First Order Fire Effects Model), a 12% measured 1000-hour fuel moisture value and a fuel-loading representative of the burn site. The model calculated a total fuel reduction of pre-burn loadings by 73%, a value within the desired prescription range. Actual consumption on the fire ground was considerably less, indicating fuel moisture levels as being higher than expected.

National Ambient Air Quality Standards (NAAQS) are affected by the amount and duration of emissions produced by a burn and the transport direction of the smoke column. Little effect to smoke sensitive areas (Los Alamos, White Rock) is likely, given the short duration of the prescribed burn project. In any case, emissions and transport direction were not monitored and so results are inconclusive.

Containment runs were modeled in BEHAVE to test the validity of the objective to contain spots and slopovers with project personnel at 5 acres or less. Rates of spread and production rates for a hand crew in a fuel model 9 were used. Burning conditions during ignition produced rates of spread in a fuel model 9 requiring a production rate 7 chains per hour to contain a 5 acre spot. The combined production rate for personnel on the project the first night was 38 chains per hour, thus this objective was achievable. A production rate of 28 chains per hour (for a running head fire) was required for given predicted rates of spread for the next afternoon's forecasted burning conditions. This would have exceeded the ability of Hiatt and Snyder, but was well within the ability of the Santa Fe Hotshots (40 chains per hour).

Potential spotting distances were computed assuming a surface fire on a ridgetop. A surface fire featuring a 9 foot flame length has the ability to spot 0.3 miles but only at the extreme high end of the prescribed windspeed (8 miles per hour). Lesser windspeeds or flame lengths modeled spotting distances no greater than 0.2 miles. Observed burning conditions during ignition and the next burn period had potential spotting distances of 0.1 miles and less.

Summary

Improvements could be made in the format and content of the Upper Frijoles Unit 1 and 5 fire plan. Prescription parameters need to be tightened down to limit tree mortality, and large fuel moistures more closely monitored to better measure unit consumption. Given the multiple fuel profiles existing in the unit, prescriptions specific to each profile would better serve to implement and monitor ignitions on the ground. Spotting and containment calculations also need to be added to the fire plan to provide a sound, scientific basis for establishing containment and contingency objectives. As it is currently written, the plan is implementable given a burn boss with local expertise and experience who understands the plans intent. A burn boss without this background would have more difficulty in appropriately implementing the plan.

/s/Daniel O'Brien, FBAN
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